[Title of Document]

Specification

[Title of Invention]

Photo-Curable Transfer Sheet, Process for the Preparation thereof, Laminate, Optical Information Recording Substrate, and Optical Information Recording Medium

[Scope of Claims for a Patent]

[Claim 1] A photo-curable transfer sheet comprising a photo-curable composition which comprises a reactive polymer having a photopolymerizable functional group and which is capable of deforming by application of pressure, at least one side of the photo-curable transfer sheet having a surface roughness (Ra) of not more than 30nm.

[Claim 2] The photo-curable transfer sheet as defined in claim 1, wherein the photo-curable composition has a glass transition temperature of not more than 20°C.

[Claim 3] The photo-curable transfer sheet as defined in claim 1 or 2, wherein the surface roughness (Ra) of not more than 10nm.

[Claim 4] The photo-curable transfer sheet as defined in any of claims 1 to 3, which further has a light transmittance of not less than 70% in a wavelength range of 380 to 420 nm.

[Claim 5] The photo-curable transfer sheet as defined in any of claims 1 to 4, which further has a light transmittance of not less than 70% in a wavelength range of 380 to 800 nm.

[Claim 6] The process as defined in any of claims 1 to 5, wherein the reactive polymer has 1 to 50% by mole of the photopolymerizable functional group.

[Claim 7] The process as defined in any of claims 1 to 6, wherein the photopolymerizable functional group is a (meth)acryloyl group.

[Claim 8] The process as defined in any of claims 1 to 7, wherein the photo-curable composition contains 0.1 to 10% by weight of a photopolymerization initiator.

[Claim 9] The process as defined in any of claims 1 to 8, wherein the photo-curable transfer sheet has a thickness of 5 to 300μm.

[Claim 10] A process for the preparation of a photo-curable transfer sheet as defined in any of claims 1 to 9 comprising:

melting a photo-curable composition which comprises a reactive polymer having a photopolymerizable functional group and which is capable of deforming by application of pressure, and

casting the melted composition onto an surface of a support having a surface roughness (Ra) of not more than 30nm.

[Claim 11] A process for the preparation of a photo-curable transfer sheet as defined in any of claims 1 to 9 comprising:

applying a coating liquid containing a photo-curable composition which comprises a reactive polymer having a photopolymerizable functional group and which is capable of deforming by application of pressure onto a surface of a support having a surface roughness (Ra) of not more than 30nm, and

drying a layer of the coating liquid.

[Claim 12] A laminate comprising a stamper having an uneven surface of recorded pits and/or grooves and the photo-curable transfer sheet as defined in any of claims 1 to 9, wherein the stamper is superposed on the photo-curable transfer sheet such that the one side of the photo-curable transfer sheet adheres closely to the uneven surface.

[Claim 13] An optical information recording substrate comprising a cured film of the photo-curable transfer sheet and having an uneven surface of recorded pits and/or grooves on one side of the cured layer, the uneven surface and a reverse side of the cured layer having a surface roughness (Ra) of not more than 30nm.

[Claim 14] An optical information recording medium comprising an optical information recording substrate having an uneven surface of recorded pits and/or grooves and a reflective layer formed on the uneven surface, and another optical information recording substrate having an uneven surface of recorded pits and/or grooves and a semitransparent reflective layer formed on the uneven surface, both the substrates being bonded to each other through an adhesive layer such that both the reflective layers face each other,

wherein at least one of the optical information recording substrates comprises a cured film of the photo-curable transfer sheet as defined in any of claims 1 to 9, the uneven surface and a reversed side of the cured layer having a surface roughness (Ra) of not more than 30nm.

[Claim 15] An optical information recording medium comprising an optical information recording substrate having an uneven surface of recorded pits and/or grooves and a reflective layer formed on the uneven surface, and another optical information recording substrate having an uneven surface of recorded pits and/or grooves and a semitransparent reflective layer formed on the uneven surface, both the substrates being bonded to each other through an adhesive layer such that a side having no reflective layer of the former substrate faces the semitransparent reflective layer of the latter substrate,

wherein at least one of the optical information recording substrates comprises a cured film of the photo-curable transfer sheet as defined in any of claims 1 to 9, the uneven surface and a reversed surface (side) of the cured layer having a surface roughness (Ra) of not more than 30nm.

[Claim 16] An optical information recording substrate comprising a cured layer of a photo-curable transfer sheet which comprises a reactive polymer having a photopolymerizable functional group and which is capable of deforming by application of pressure, one side of the cured layer having an uneven surface of recorded pits and/or grooves,

wherein a coating layer of ultraviolet curable resin is provided on the other side having no unevenness of the cured layer and cured to form cured layer as a surface smoothed layer which has a surface roughness (Ra) of not more than 30nm.

[Claim 17] An optical information recording medium comprising an optical information recording substrate having an uneven surface of recorded pits and/or grooves and a reflective layer formed on the uneven surface, and another optical information recording substrate having an uneven surface of recorded pits and/or grooves and a semitransparent reflective layer formed on the uneven surface, both the substrates being bonded to each other through an adhesive layer such that both the reflective layers face each other,

wherein at least one of the optical information recording substrates comprises a cured layer of the photo-curable transfer sheet which comprises a reactive polymer having a photopolymerizable functional group and is capable of deforming by application of pressure, and

wherein a coating layer of ultraviolet curable resin is provided on the other side having no unevenness of the cured layer by application and cured to form a cured layer as a surface smoothed layer which has a surface roughness (Ra) of not more than 30nm.

[Claim 18] An optical information recording medium comprising an optical information recording substrate having an uneven surface of recorded pits and/or grooves and a reflective layer formed on the uneven surface, and another optical information recording substrate having an uneven surface of recorded pits and/or grooves and a semitransparent reflective layer formed on the uneven surface, both the substrates being bonded to each other through an adhesive layer such that a side having no reflective layer of the former substrate faces the semitransparent reflective layer of the latter substrate,

wherein a layer comprising at least uneven surface of at least one of

the optical information recording substrates comprises a cured layer of the photo-curable transfer sheet which comprises a reactive polymer having a photopolymerizable functional group and is capable of deforming by application of pressure,

wherein a coating layer of ultraviolet curable resin is provided on the other side having no unevenness of the cured layer by application and cured to form a cured layer as a surface smoothed layer which has a surface roughness (Ra) of not more than 30nm.

[Claim 19] The optical information recording medium as defined in any of claims 16 to 18, wherein the photo-curable composition has a glass transition temperature of not more than 20°C.

[Claim 20] The optical information recording medium as defined in any of claims 16 to 19, wherein the surface roughness (Ra) of not more than 10nm.

[Claim 21] The optical information recording medium as defined in any of claims 16 to 20, which further has a light transmittance of not less than 70% in a wavelength range of 380 to 420 nm.

[Claim 22] The optical information recording medium as defined in any of claims 16 to 21, which further has a light transmittance of not less than 70% in a wavelength range of 380 to 800 nm.

[Claim 23] The optical information recording medium as defined in any of claims 16 to 22, wherein the reactive polymer has 1 to 50% by mole of the photopolymerizable functional group.

[Claim 24] The optical information recording medium as defined in any of claims 16 to 23, wherein the photopolymerizable functional group is a (meth)acryloyl group.

[Claim 25] The optical information recording medium as defined in any of claims 16 to 24, wherein the photo-curable composition contains 0.1 to 10% by weight of a photopolymerization initiator.

[Claim 26] The optical information recording medium as defined in any

of claims 16 to 25, wherein the photo-curable transfer sheet has a thickness of 5 to 300μm.

[Detailed Description of the Invention]
[Technical Field]
[0001]

The present invention relates to an optical information recording medium, such as DVD (Digital Versatile Disc), CD (Compact Disc), an optical magnetic disc or a hard disc, in which a large amount of information such as letters, sound and animation is recorded and/or recordable as digital signals, an optical information recording substrate, and a process for the preparation thereof, and further a photo-curable transfer sheet in the preparation of the substrate, and a laminate.

[Prior Art]
[0002]

As an optical information recording medium in which digital signals have been already recorded by forming pits on its surface, CD and CD-ROM are widely used. Recently, DVD that animation can be also recorded by forming pits on its both (double) sides has been noted as the next generation recording medium instead of CD and increasingly used. Further, attention is directed to recordable discs such as CD-R, DVD-R and DVD-RW having groove(s) or grooves and pits thereon.

[0003]

Conventional DVD having recording layers on its both sides includes a disc readable from double sides, as shown in, for example, Fig. 6, in which each of reflective layers 1a, 2a is formed on a surface of signal-pits of each of transparent resin substrates 1, 2 having the surface of signal-pits on its one side, and the two transparent resin substrates 1, 2 are bonded to each other through an adhesive layer 3 such that the reflective

layers 1a, 2a face each other; and a disc readable from single side, as shown in, for example, Fig. 7, in which a semitransparent reflective layer 1b is formed on a surface of signal-pits of one transparent resin substrate 1 while a reflective layers 2a is formed on a surface of signal-pits of another transparent resin substrate 2 and the two transparent resin substrates 1, 2 are bonded to each other through an adhesive layer 3 such that the semi-transparent reflective layers 1b and the reflective layer 2a face each other.

[0004]

The DVD readable from double sides can be prepared, for example, by subjecting melted polycarbonate resin to injection molding by the use of a stamper having unevenness (concave and convex) corresponding to the reverse of unevenness of the signal-pit to be recorded on the substrate to prepare a transparent resin substrate having unevenness on its surface, forming a reflective layer on the uneven surface by spattering metal such as aluminum on it, and bonding two transparent resin substrates obtained in the above manner to each other through an adhesive such that the two reflective layers face each other.

[Problem to be solved by the Invention]

[0005]

As mentioned above, though a transparent resin substrate (optical information recording substrate) of DVD is prepared by injection molding of polycarbonate, the formation of pits by the injection molding brings about reduction of precision of pit shape transferred from the stamper to the polycarbonate resin, particularly in case of a substrate having thickness of 300μm or less (see JA11-273147). Further, the present inventors have found a problem that a land portion of the surface having the pits comes to rough.

[0006]

With increase of information to be recorded, a new optical informa-

tion recording medium, which has lager storage capacity than DVD now on use, is expected. To obtain the large storage capacity, it is required to not only reduce sizes of signal pits and a groove but also shorten a wavelength of recording or reading laser. Further the shortening of the wavelength reduces distance between the laser and a surface having the pits and therefore it is needed to reduce a thickness of the optical information recording substrate.

[0007]

JA11-273147 mentioned above describes that a pressure-sensitive adhesive sheet or a dry photopolymer in addition to the liquid UV curable resin is used for bonding a transparent film to an injection molded substrate having an uneven surface. Therefore, there is no description with respect to use of the dry photopolymer for forming uneven surface.

[0008]

The present applicant filled a patent application as to a photo-curable transfer sheet having a little shrinkage on curing to which an unevenness surface of a stamper for preparing a substrate of an optical information recording medium can be easily and precisely transferred by depression, and especially by which a thin substrate having thickness of 300μm or less can be advantageously prepared (Patent Application No. 2001-305946). Though this sheet has a little shrinkage on curing, it does not occasionally have sufficiently excellent smooth surface. In more detail, a surface having no unevenness of the substrate corresponds to a side irradiated by a laser for recording and/or reading out, and therefore when the surface is rough, errors are apt to occur in the operation for recording and/or reading out.

[0009]

In view of the above-mentioned problems, the object of the invention is to provide a photo-curable transfer sheet having sufficiently an excellent smooth surface to which an uneven surface of a stamper for prepar-

ing a substrate of an optical information recording medium can be easily and precisely transferred by depression, and especially by which a thin substrate having thickness of 300μm or less can be advantageously prepared.

[0010]

Further, the object of the invention is to provide a process for the preparation of the above-mentioned photo-curable transfer sheet.

[0011]

Furthermore, the object of the invention is to provide a optical information recording substrate suitable for preparing an optical information recording medium having one surface onto which unevenness of a stamper is precisely transferred and the other surface having excellent smoothness (laser-irradiation side).

[0012]

Moreover, the object of a third aspect of the invention is to provide an optical information recording medium having precisely formed pit signals and/or groove on one side and excellent smoothness on the other side (laser-irradiation side).

[Means for Achieving Object]

[0013]

Hence, the invention is provided by a photo-curable transfer sheet comprising a photo-curable composition which comprises a reactive polymer having a photopolymerizable functional group and which is capable of deforming by application of pressure, at least one side of the photo-curable transfer sheet having a surface roughness (Ra) of not more than 30nm (especially not more than 10nm).

[0014]

In the photo-curable transfer sheet, the photo-curable composition preferably has a glass transition temperature of not more than 20°C, which

makes the formation of unevenness by depression at room temperature easy. The photo-curable transfer sheet generally has a light transmittance of not less than 70% in a wavelength rang of 380 to 420nm, preferably in a wavelength rang of 380 to 600nm, especially in a wavelength rang of 380 to 800nm. It is ensured that an optical disc obtained by using the transfer sheet having the light transmittance is operated without error if the disc is read out by irradiation of laser. Moreover, the photo-curable transfer sheet generally has cure shrinkage of not more than 8%.

[0015]

Further, the reactive polymer preferably has 1 to 50% by mole of the photopolymerizable functional group whereby appropriate curing property of the polymer or appropriate strength of the cured polymer is ensured. The photopolymerizable functional group generally is a (meth)acryloyl group in terms of curing property. The photo-curable composition generally contains 0.1 to 10% by weight of a photopolymerization initiator. The photo-curable transfer sheet preferably has a thickness of 5 to 300μm in terms of transferring properties and workability.

[0016]

The photo-curable transfer sheet can be advantageously obtained by a process comprising:

melting a photo-curable composition which comprises a reactive polymer having a photopolymerizable functional group and which is capable of deforming by application of pressure, and

casting the melted composition onto an surface of a support, the surface having a surface roughness (Ra) of not more than 30nm; or

a process comprising:

applying a coating liquid containing a photo-curable composition which comprises a reactive polymer having a photopolymerizable functional group and which is capable of deforming by application of pressure onto a surface of a support, the surface having a surface roughness (Ra) of

not more than 30nm, and

drying a layer of the coating liquid.

[0017]

In the invention, there is provided by a laminate in which a stamper having an uneven surface of recorded pits and/or grooves is superposed on the photo-curable transfer sheet such that the one side of the photo-curable transfer sheet adheres closely to the uneven surface.

[0018]

Further, there is provided by:

an optical information recording substrate comprising a cured film of the photo-curable transfer sheet and having an uneven surface of recorded pits and/or grooves on one side of the cured layer, the uneven surface and a reverse surface (side) of the cured layer having a surface roughness (Ra) of not more than 30nm;

an optical information recording medium comprising an optical information recording substrate having an uneven surface of recorded pits and/or grooves and a reflective layer formed on the uneven surface, and another optical information recording substrate having an uneven surface of recorded pits and/or grooves and a semitransparent reflective layer formed on the uneven surface, both the substrates being bonded to each other through an adhesive layer such that both the reflective layers face each other,

wherein at least one of the optical information recording substrates comprises a cured film of the photo-curable transfer sheet, the uneven surface and a reversed surface (side) of the cured layer having a surface roughness (Ra) of not more than 30nm; and

an optical information recording medium comprising an optical information recording substrate having an uneven surface of recorded pits and/or grooves and a reflective layer formed on the uneven surface, and another optical information recording substrate having an uneven surface of

recorded pits and/or grooves and a semitransparent reflective layer formed on the uneven surface, both the substrates being bonded to each other through an adhesive layer such that a side having no reflective layer of the former substrate faces the semitransparent reflective layer of the latter substrate,

wherein at least one of the optical information recording substrates comprises a cured film of the photo-curable transfer sheet, the uneven surface and a reversed surface (side) of the cured layer having a surface roughness (Ra) of not more than 30nm.

[0019]

Moreover, there is provided by:

an optical information recording substrate comprising a cured layer of a photo-curable transfer sheet which comprises a reactive polymer having a photopolymerizable functional group and which is capable of deforming by application of pressure, one side of the cured layer having an uneven surface of recorded pits and/or grooves, wherein a coating layer of ultraviolet curable resin is provided on the other side having no unevenness of the cured layer and cured to form cured layer as a surface smoothed layer which has a surface roughness (Ra) of not more than 30nm;

an optical information recording medium comprising an optical information recording substrate having an uneven surface of recorded pits and/or grooves and a reflective layer formed on the uneven surface, and another optical information recording substrate having an uneven surface of recorded pits and/or grooves and a semitransparent reflective layer formed on the uneven surface, both the substrates being bonded to each other through an adhesive layer such that both the reflective layers face each other,

wherein at least one of the optical information recording substrates comprises a cured layer of the photo-curable transfer sheet which comprises a reactive polymer having a photopolymerizable functional group

and weight-average molecular weight of not less than 5,000 and is capable of deforming by application of pressure, and

wherein a coating layer of ultraviolet curable resin is provided on the other side having no unevenness of the cured layer by application and cured to form a cured layer as a surface smoothed layer which has a surface roughness (Ra) of not more than 30nm; and

an optical information recording medium comprising an optical information recording substrate having an uneven surface of recorded pits and/or grooves and a reflective layer formed on the uneven surface, and another optical information recording substrate having an uneven surface of recorded pits and/or grooves and a semitransparent reflective layer formed on the uneven surface, both the substrates being bonded to each other through an adhesive layer such that a side having no reflective layer of the former substrate faces the semitransparent reflective layer of the latter substrate,

wherein a layer comprising at least uneven surface of at least one of the optical information recording substrates comprises a cured layer of the photo-curable transfer sheet which comprises a reactive polymer having a photopolymerizable functional group and weight-average molecular weight of not less than 5,000 and is capable of deforming by application of pressure,

wherein a coating layer of ultraviolet curable resin is provided on the other side having no unevenness of the cured layer by application and cured to form a cured layer as a surface smoothed layer which has a surface roughness (Ra) of not more than 30nm.

[0020]

In the optical information recording medium, the surface roughness (Ra) preferably is not more than 10nm. The photo-curable composition preferably has a glass transition temperature of not more than 20°C. The photo-curable transfer sheet generally has a light transmittance of not less

than 70% in a wavelength rang of 380 to 420nm, preferably in a wavelength rang of 380 to 800nm. Further, the reactive polymer preferably has 1 to 50% by mole of the photopolymerizable functional group. The photopolymerizable functional group generally is a (meth)acryloyl group. The photo-curable composition generally contains 0.1 to 10% by weight of a photopolymerization initiator. The photo-curable transfer sheet preferably has a thickness of 5 to 300μm.

[Best Mode for Conducting the Invention]

[0021]

Embodiments of the invention are explained in detail by referring to drawings.

[0022]

Fig. 1 (a) and (b) is a section view showing examples of embodiments of the photo-curable transfer sheet 11 used in the present invention. In Fig. 1 (a), the photo-curable transfer sheet 11 has a release sheet 12a on its one side and a release sheet 12a on the other side. The release sheet may be provided on one side, and otherwise may not be provided, depending on uses. In Fig. 1 (b), the photo-curable transfer sheet 11 has a release sheet 12a on its one side and a support 12c on the other side.

[0023]

The photo-curable transfer sheet 11 according to the third aspect has an excellent smooth surface, and its surface roughness (Ra) is not more than 30nm, preferably not more than 10nm. The photo-curable transfer sheet 11 having an excellent smooth surface can be obtained, for example, by casting a melt of a photo-curable composition which comprises a reactive polymer having a photopolymerizable functional group and which is capable of deforming by application of pressure on a surface of a support, the surface having a surface roughness (Ra) of not more than 30nm. Example of the support includes a film made of polycarbonate, which is

commercially available. Otherwise, the photo-curable transfer sheet 11 can be obtained, for example, by applying a coating liquid of the above photo-curable composition onto a surface of the support having a surface roughness (Ra) of not more than 30nm (especially not more than 10nm), and drying a layer of the coating liquid. However, the former method is preferred since it brings about a lower surface roughness.

[0024]

It is preferred that the photo-curable transfer sheet 81 is mainly composed of a photo-curable composition which comprises a reactive polymer having a photopolymerizable functional group and a glass transition temperature of not more than 20°C. Further, the photo-curable transfer sheet has a light transmittance of not less than 70% in a wavelength range of 380 to 420 nm such that information can be easily read out by a reproduction laser. The light transmittance is preferably not less than 80% in a wavelength range of 380 to 420 nm. Hence, an optical information recording medium obtained by using the transfer sheet can be advantageously used in a process for reproducing pit signals by using a reproduction laser having a laser wavelength in the range of 380 to 420 nm.

[0025]

The optical information recording substrate and laminate can be prepared using the above photo-curable transfer sheet 11, for example, as shown in Fig. 2.

[0026]

When the photo-curable transfer sheet 11 having release sheets 12a, 12b on both sides is used, the preparation is carried out below. The release sheet 12b is removed from the photo-curable transfer sheet 11, and the transfer sheet is disposed on an uneven surface of a stamper 21 having the uneven surface of recorded pits such that a surface having no release sheet of the photo-curable transfer sheet 11 faces the uneven surface, and they are superposed and depressed such that the photo-curable transfer

sheet 11 is brought into close contact with the uneven surface, whereby a laminate having the stamper 21 and the photo-curable transfer sheet 11 according to the invention is obtained. Then, the release sheet 12a of the photo-curable transfer sheet 11 is exposed to UV (ultraviolet rays), whereby the photo-curable transfer sheet 11 is cured and then the stamper 21 and the release sheet 12a are removed from the laminate to obtain the cured photo-curable transfer sheet 20 having unevenness (i.e., optical information recording substrate) . The surface having no unevenness of this substrate has a surface roughness (Ra) is not more than 30nm, preferably not more than 10nm.

[0027]

In case the photo-curable transfer sheet 11 (shown in Fig. 1(b)) having a release sheet 12a on its one side and a support 82c on the other side is used, the resultant substrate has a smooth surface of the support and both smooth surfaces in the interface between the support and transfer sheet, these surfaces having a surface roughness (Ra) being not more than 30nm, preferably not more than 10nm.

[0028]

In the invention, the photo-curable transfer sheet is configured such that the uneven shape of recorded pits of the stamper 21 can be precisely transferred to the photo-curable transfer sheet by depressing the sheet onto the stamper at low temperature of 100°C or less. Superposition of the stamper 21 and the photo-curable transfer sheet 11 is generally carried out using a pressure rollers or easy press, preferably under reduced pressure. The photo-curable transfer sheet 11 after curing is weakly stuck to metal such as nickel used in the stamper, and therefore the photo-curable transfer sheet 11 can be easily peeled from the stamper 21.

[0029]

The optical information recording medium can be prepared using the above-mentioned optical information recording substrate 20, for exam-

ple, as shown in Fig. 3.

[0030]

The uneven surface of the optical information recording substrate 20 obtained above is metallized (deposited) by sputtering process using silver alloy, whereby a silver-alloy reflective layer (semitransparent reflective layer) 13 is formed on the substrate. Separately, the uneven surface of an optical information recording substrate 40 is metallized by sputtering process using aluminum, whereby an Al reflective layer 33 (or silver-alloy reflective layer having higher reflectivity than the layer) is formed on the substrate. The substrate 20 having the semitransparent reflective layer 13 and the substrate 30 having the Al reflective layer 33 are disposed such that both the reflective layers face each other and superposed through an adhesive, and the adhesive is cured to form an adhesive layer 34, whereby the optical information recording medium 40 is obtained. The surface having no unevenness of the sheet 11 of this optical information recording medium 40 has a surface roughness (Ra) of not more than 30nm (especially not more than 10nm). Since reading of signals is carried out by exposing a reproduction light (laser) to the surface, there are little errors in reading. On this surface, further a support or a protective film may be provided.

[0031]

In the above process, the optical information recording medium exclusively used for reproduction is explained. On the other hand, in the recordable medium, for example, grooves or grooves and pits is provided instead of the pits, and a metal recording layer is provided instead of the reflective layer or semitransparent reflective layer. When the recording layer is a dye-recording layer, a recording layer and reflective layer are provided. Besides the points, the recordable medium is prepared in the same manner as the above process.

[0032]

The optical information recording substrate 30, which is generally a

thick plate, may be prepared by a conventional injection molding or by the process for the preparation of the optical information recording substrate as mentioned previously. The optical information recording substrate can be prepared so as to have a thickness of 300μm or less, and therefore, when another substrate is prepared by a conventional process, the thickness of the another substrate can be increased to enhance the precision of pit and/or groove shape. The adhesives used for forming the adhesive layer include a conventional hot-melt type adhesive, a UV-curable resin adhesive and a pressure-sensitive contact adhesive.

[0033]

Further, the following media are preferred: Two optical information recording substrates 30 mentioned above, i.e., one substrate having a full reflective layer such as Al layer and the other substrate having a semitransparent reflective layer, are prepared, the two substrates are bonded to each other through an adhesive such that the semitransparent reflective layer faces the surface having no unevenness to form a laminate, and another laminate is prepared in the same manner as above, the resultant two laminates are bonded to each other through an adhesive such that both the reflective layers face each other, and hence an optical information recording medium having four recorded surfaces is obtained. Further, the above one laminate is bonded onto a transparent supporting substrate whereby an optical information recording medium shown in Fig. 4 can be obtained. Furthermore, the above one laminate is bonded onto a conventional transparent supporting substrate having uneven surface and a reflective layer thereon to give an optical information recording medium. In these media, the semitransparent reflective layer is provided on the incident side of the reading laser beam.

[0034]

These media can be used as conventional four-layer type and three-layer type in double sides reading system and two-layer type in single

side reading system, respectively.

[0035]

Otherwise, unevenness is formed on a part of a substrate, a reflective layer is formed thereon, and a recording layer, on which information can be written, may be provided thereon.

[0036]

Based on the process explained above by referring to Figs. 2 and 3, another procedure to obtain the optical information recording medium having the specific surface roughness is described below. The procedure is carried out by using a photo-curable transfer sheet having no smooth surface instead of the transfer sheet having the specific surface roughness and, after preparation of a laminate, giving surface smoothness to the resultant laminate. This procedure can be also applied to the case that the transfer sheet of the medium has insufficiently smooth surface, which results from treatments during the preparation of medium even if a release sheet having excellent smooth surface is used, or from the use of a release sheet having poor smooth surface.

[0037]

In Fig. 2, after the preparation of the optical information recording substrate 20 (i.e., cured photo-curable transfer sheet having unevenness 11), a coating liquid of ultraviolet curable resin is applied onto the reverse surface having no unevenness of the substrate by a spin coater or a screen printing method and the resultant coating liquid layer is exposed to ultraviolet rays for curing the layer, in order to enhance smoothness of the surface. The coating liquid of an ultraviolet curable resin mainly comprises compounds having a photopolymerizable functional group(s) and a photopolymerization initiator as described later, and further a surfactant such as a leveling agent and if desired an organic solvent. Further, in order to enhance the smoothness of the surface, in addition to the surfactant such as a leveling agent, polymers described later may be added to the coating liquid. Besides the above additives, the coating liquid may

Besides the above additives, the coating liquid may contain a UV light absorber, an aging resistant agent, a dye and/or a processing auxiliary. If necessary, the coating liquid may contain a particle of material such as silica gel, calcium carbonate or silicone copolymer in a small amount. It is generally preferred to use an ultraviolet curable resin for forming hard coat layer, which has excellent leveling prosperity and also can give high hardness.

[0038]

The conditions for application of the coating liquid generally include viscosity of the coating liquid in the range of 10 to 1,000 [mPas/25°C], the setting time in the range of 1 to 100 sec., the exposing time in the range of 1 to 20 sec., and the thickness in the range of 1 to 10μm.

[0039]

The application of the coating liquid can be carried out in an appropriate step in the process shown in Fig. 3. For example, the application can be carried out after metal is sputtered, or after the medium is finished.

[0040]

In the process, when the photo-curable transfer sheet is depressed on the stamper, or when the two optical information recording substrates are superposed on each other through adhesive such that the reflective layers face each other, it is preferred to carry out the depressing or superposing operation under reduced pressure whereby bubbles generated in the operation can be smoothly moved.

[0041]

The depressing operation under the reduced pressure can be performed by a method comprising passing the photo-curable transfer sheet and stamper between two rolls under reduced pressure; or by a method comprising placing a stamper in a mold of a vacuum molding device and contact bonding a photo-curable transfer sheet to the stamper under re-

duced pressure.

[0042]

Further, the depressing operation under the reduced pressure can be performed using a device according to a double vacuum chamber system. The operation is explained by referring to Fig. 5. Fig. 5 shows a laminator according to a double vacuum chamber system. The laminator is provided with a lower chamber 51, an upper chamber 52, a sheet of silicone rubber 53 and a heater 55. A laminate 59 consisting of a substrate having unevenness and a photo-curable transfer sheet provided thereon or a laminate 59 consisting of two substrates having uneven surface bonded by adhesive is placed in the lower chamber 51 of the laminator. Both the upper chamber 52 and lower chamber 51 are degassed or decompressed. The laminate 59 is heated with a heater 55, and air is introduced into the upper chamber 52 to allow the chamber to be at atmospheric pressure while the lower chamber 51 is kept under reduced pressure, whereby the laminate is depressed to be contact bonded. After cooling, the laminate is taken out and transformed to the next step. This operation permits sufficient deaeration under reduced pressure, and therefore, the substrate and the photo-curable transfer sheet can be contact bonded without bubbles.

[0043]

The photo-curable transfer sheet used in the invention preferably comprises a photo-curable composition which comprises a reactive polymer having a photopolymerizable functional group and a glass transition temperature of not more than 20°C.

[0044]

The photo-curable composition is generally composed mainly of the reactive polymer having a photopolymerizable functional group, a compound (e.g., monomer or oligomer) having a photopolymerizable functional group (preferably (meth)acryloyl group), a photopolymerization initiator and if necessary other additives.

[0045]

Examples of the reactive polymer having a photopolymerizable functional group include homopolymers or copolymers (i.e., acrylic resins having a photopolymerizable functional group) derived from alkyl acrylate (e.g., methyl acrylate, ethyl acrylate, butyl acrylate, 2-ethylhexyl acrylate) and/or alkyl methacrylate (e.g., methyl methacrylate, ethyl methacrylate, butyl methacrylate, 2-ethylhexyl methacrylate) and having a photopolymerizable functional group on its main chain or side chain. These (co)polymers can be obtained, for example, by copolymerizing one or more (meth)acrylate mentioned above with (meth)acrylate (e.g., 2-hydroxyethyl (meth)acrylate) having a functional group such as -OH and reacting the resultant polymer with a compound (e.g., isocyanatoalkyl (meth)acrylate) having a functional group capable of reacting with the functional group of the polymer and having a photopolymerizable functional group.

[0046]

The reactive polymer of the invention has generally 1 to 50% by mole, preferably 5 to 30% by mole of the photopolymerizable functional group. Examples of the photopolymerizable functional group preferably include acryloyl, methacryloyl and vinyl groups, especially acryloyl and methacryloyl groups.

[0047]

In case the reactive polymer having glass transition temperature of not more than 20°C (preferably not more than 10°C) is used as above, the resultant photo-curable transfer layer having flexibility can follow exactly the uneven surface of the stamper even at room temperature when the sheet is depressed on the stamper. The reactive polymer especially has glass transition temperature of 15 to -50°C because the resultant photo-curable layer can follow more exactly the uneven surface. When the glass transition temperature exceeds the upper limit, high pressure and temperature is needed in the depressing and bonding steps of the sheet, which brings about

lowering of workability. When the glass transition temperature falls to below the lower limit, the resultant cured sheet does not have sufficient hardness.

[0048]

The reactive polymer of the invention generally has number-average molecular weight of 5,000 to 1,000,000, preferably 10,000 to 300,000, and/or generally has weight-average molecular weight of 5,000 to 1,000,000, preferably 10,000 to 300,000.

[0049]

Examples of the compounds having a photopolymerizable group include (meth)acrylate monomers such as 2-hydroxyethyl (meth)acrylate, 2-hydroxyropyl (meth)acrylate, 4-hydroxybutyl (meth)acrylate, 2-ethylhexylpolyethoxy (meth)acrylate, benzyl (meth)acrylate, isobornyl (meth)acrylate, phenyloxyethyl (meth)acrylate, tricyclodecane mono(meth)acrylate, dicyclopentenyloxyethyl (meth)acrylate, tetrahydrofurfuryl (meth)acrylate, acryloylmorpholine, N-vinylcaprolactam, 2-hydroxy-3-phenyloxypropyl (meth)acrylate, o-phenylphenyloxyethyl (meth)acrylate, neopentylglycol di(meth)acrylate, neopentyl glycol dipropoxy di(meth)acrylate, neopentyl glycol hydroxypivalate di(meth)acrylate, tricyclodecanedimethylol di(meth)acrylate, 1,6-hexanediol di(meth)acrylate, nonanediol di(meth)acrylate, trimethylolpropane tri(meth)acrylate, pentaerythritol tri(meth)acrylate, pentaerythritol tetra(meth)acrylate, tris[(meth)acryloxyethyl]isocyanurate and ditrimethylolpropane tetra(meth)acrylate; and

the following (meth)acrylate oligomer such as:

polyurethane (meth)acrylate such as compounds obtained by reaction of:

a polyol compound (e.g., polyol such as ethylene glycol, propylene glycol, neopentyl glycol, 1,6-hexanediol, 3-methyl-1,5-pentanediol, 1,9-nonanediol, 2-ethyl-2-butyl-1,3-propanediol, trimethylolpropane, di-

ethylene glycol, dipropylene glycol, polypropylene glycol, 1,4-dimethylolcyclohexane, bisphenol-A polyethoxydiol and polytetramethylene glycol; polyesterpolyol obtained by reaction of the above-mentioned polyol and polybasic acid or anhydride thereof such as succinic acid, maleic acid, itaconic acid, adipic acid, hydrogenated dimer acid, phthalic acid, isophthalic acid and terephthalic acid; polycaprolactone polyol obtained by reaction of the above-mentioned polyol and ε-caprolactone; a compound obtained by reaction of the above-mentioned polyol and a reaction product of the above-mentioned polybasic acid or anhydride thereof and ε-caprolactone; polycarbonate polyol; or polymer polyol), and

an organic polyisocyanate compound (e.g., tolylene diisocyanate, isophorone diisocyanate, xylylene diisocyanate, diphenylmethane-4,4'-diisocyanate, dicyclopentanyl diisocyanate, hexamethylene diisocyanate, 2,4,4'-trimethylhexamethylene diisocyanate, 2,2',4'-trimethylhexamethylene diisocyanate), and

hydroxyl-containing (meth)acrylate (e.g., 2-hydroxyethyl (meth)acrylate, 2-hydroxyropyl (meth)acrylate, 4-hydroxybutyl (meth)acrylate, 2-hydroxy-3-phenyloxypropyl (meth)acrylate, cyclohexane-1,4-dimethylolmono(meth)acrylate, pentaerythritol tri(meth)acrylate or glycerol di(meth)acrylate);

bisphenol-type epoxy(meth)acrylate obtained by reaction of bisphenol-A epoxy resin or bisphenol-F epoxy resin and (meth)acrylic acid.

These compounds having photopolymerizable functional group can be employed singly or in combination of two or more kinds.

[0050]

Any photopolymerization initiators known can be used in the invention. The initiators having good storage-stability after mixing with other components are preferred. Examples of the photopolymerization initiators include acetophenone type initiators such as

2-hidroxy-2-methyl-1-phenylpropane-1-on, 1-hydroxycyclohexylphenylketone and 2-methyl-1-[4-(methylthio)phenyl]-2-morphorino-propane-1-on; benzoin type initiators such as benzylmethylketal; benzophenone type initiators such as benzophenone, 4-phenylbenzophenone and hydroxybenzophenone; thioxanthone type initiators such as isopropylthioxanthone and 2,4-diethythioxanthone. Further, as special type, there can be mentioned methylphenylglyoxylate. Especially preferred are 2-hidroxy-2-methyl-1-phenylpropane-1-on, 1-hydroxycyclohexylphenylketone, 2-methyl-1-[4-(methylthio)phenyl]-2-morphorinopropane-1-on and benzophenone. These photopolymerization initiators can be employed together with one or more kinds of a photopolymerization promoter such as a benzoic acid type compound (e.g., 4-dimethylaminobezoic acid) or a tertiary amine compound by mixing the initiator with the promoter in optional ratio. Only the initiator can be employed singly or in combination of two or more kinds. The initiator is preferably contained in the photo-curable composition in the range of 0.1 to 20% by weight, particularly 1 to 10% by weight.

[0051]

In addition to the above-mentioned photopolymerizable initiators, the acetophenone type initiator includes 4-phenoxydichloroacetophenone, 4-t-butyldichloroacetophenone, 4-t-butyltrichloroacetophenone, diethoxyacetophenone, 2-hidroxy-2-methyl-1-phenylpropane-1-on, 1-(4-isopropylphenyl)-2-hidroxy-2-methylpropane-1-on, 1-(4-dodecylphenyl)-2-hydroxy-2-methylpropane-1-on, 4-(2-hydroxyethoxy)-phenyl(2-hydroxy-2-propyl)ketone, 1-hydroxycyclohexylphenylketone, 2-methyl-1-[4-(methylthio)phenyl]-2-morphorino-propane-1-on; and the benzophenone type initiators include benzophenone, benzoylbenzoic acid, methyl benzoylbenzoate, 4-phenylbenzophenone, hydroxybenzophenone,

4-benzoyl-4'-methylphenylsulfide and 3,3'-dimethyl-4-methoxybenzophenone.

[0052]

The acetophenone type initiators preferably are 2-hidroxy-2-methyl-1-phenylpropane-1-on, 1-hydroxycyclohexylphenylketone, 2-methyl-1-[4-(methylthio)phenyl]-2-morphorinopropane-1-on, and the benzophenone type initiators preferably are benzophenone, benzoylbenzoic acid and methyl benzoylbenzoate. Preferred examples of the tertiary amine compounds of the photopolymerization promoter include triethanolamine, methyldiethanolamine, triisopropanolamine, 4,4'-dimethylaminobenzophenone, 4,4'-diethylaminobenzophenone, ethyl 2-dimethylaminobenzonate, ethyl 4-dimethylaminobenzonate, (n-butoxy)ethyl 4-dimethylaminobenzonate, isoamyl 4-dimethylaminobenzonate and 2-ethylhexyl 4-dimethylaminobenzonate. Especially preferred are ethyl 4-dimethylaminobenzonate, (n-butoxy)ethyl 4-dimethylaminobenzonate, isoamyl 4-dimethylaminobenzonate and 2-ethylhexyl 4-dimethylaminobenzonate. As mentioned above, three kinds of components of the photopolymerizable initiators can be combined.

[0053]

The photo-curable composition of the invention is preferably configured such that the photo-curable transfer sheet before and after curing has a glass transition temperature of not more than 20°C and the photo-curable transfer sheet has a transmittance of not less than 70%. Therefore the photo-curable composition preferably contains, in addition to the compound having a photopolymerizable functional group and the photopolymerization initiator, if desired the following thermoplastic resin and other additives.

[0054]

The ratio by weight of the reactive polymer : the compound having

a photopolymerizable functional group : the photopolymerization initiator generally is 40-100 : 0-60 : 0.1-10, especially 60-100 : 0-40 : 1-10.

[0055]

As other additives, a silane coupling agent can be used for enhancing the adhesive strength. Examples of the silane coupling agent include vinyltriethoxysilane, vinyltris(β-methoxyethoxy)silane, γ-methacryloxypropylmethoxysilane, vinyltriacetoxysilane, γ-glycidoxypropyltrimethoxysilane, γ-glycidoxypropyltriethoxysilane, β-(3,4-epoxycyclohexyl)ethyltrimethoxysilane, γ-chloropropylmethoxysilane, vinyltrichlorosilane, γ-mercaptopropylmethoxysilane, γ-aminopropyltriethoxysilane, N-β-(aminoethyl)-γ-aminopropyltrimethoxysilane. The silane coupling agent can be used singly, or in combination of two or more kinds. The silane coupling agent is preferably used in the range of 0.01 to 5 weight by part based on 100 parts by weight of the above reactive polymer.

[0056]

Similarly, an epoxy group-containing compound can be used for enhancing the adhesive strength. Examples of the epoxy group-containing compounds include triglycidyl tris(2-hydroxyethyl)isocyanurate, neopentylglycol diglycidyl ether, 1,6-hexanediol diglycidyl ether, allyl glycidyl ether, 2-ethylhexyl glycidyl ether, phenyl glycidyl ether, phenol glycidyl ether, p-tert-butylphenyl glycidyl ether, diglycidyl adipate, diglycidyl o-phthalate, glycidyl methacrylate and butyl glycidyl ether. Further, the similar effect is also obtained by using an oligomer having an epoxy group and molecular weight of hundreds to thousands, or a polymer having an epoxy group and molecular weight of thousands to hundreds of thousands. The content of the compound having an epoxy group is sufficient in the range of 0.1 to 20 parts by weight based on 100 parts by weight of the reactive polymer, particularly 1 to 10% by weight. At least one of the compounds having an epoxy group

can be used singly or in combination of two or more kinds.

[0057]

As other additives, further a hydrocarbon resin can be used for improving processing properties such as laminating properties. The hydrocarbon resin may be either natural resin or synthetic resin. Examples of the natural resins preferably include rosins, rosin derivatives and terpene resins. Examples of the rosins include gum resins, tall oil resins, wood resins. Examples of the rosin derivatives include hydrogenated rosins, disproportionated rosins, polymerized rosins, esterificated rosins, metal salts of rosins. Examples of the terpene resins include α-pinene resins, β-pinene resins, and terpene phenol resins. Moreover, as the natural resin, dammar, copal, shellac can be used. Examples of the synthetic resins preferably include petroleum resins, phenol resins, and xylene resins. Examples of the petroleum resins include aliphatic petroleum resins, aromatic petroleum resins, cycoaliphatic petroleum resins, copolymer type petroleum resins, hydrogenated petroleum resins, pure monomer type petroleum resins, and coumarone-indene resins. Examples of the phenol resins include alkylphenol resins and modified phenol resins. Examples of the xylene resins include xylene resins and modified xylene resins.

[0058]

Furthermore, acrylic resin can be employed in the invention. For example, homopolymers and copolymers obtained from alkyl acrylate(s) such as methyl acrylate, ethyl acrylate and butyl acrylate and/or alkyl methacrylate(s) such as methyl methacrylate, ethyl methacrylate and butyl methacrylate can be used. Copolymers of these monomers and other copolymerizable monomers can be also used. In view of reactivity in the photo curing step and durability and transparency of cured product, polymethyl methacrylate (PMMA) is preferred.

[0059]

The above-mentioned polymer such as hydrocarbon resin can be

used in the amount of 1 to 20 parts by weight, preferably 5 to 15 parts by weight based on 100 parts by weight of the reactive polymer.

[0060]

The photo-curable composition may contain, in addition to the above-mentioned additives, an ultraviolet absorber, an aging resistant agent, a dye, and a processing auxiliary agent in a small amount. If desired, particles of silica gel, calcium carbonate or silicone copolymer may be contained in a small amount.

[0061]

The photo-curable transfer sheet (including type making no consideration as to smoothness of surface) comprising the photo-curable composition of the invention is generally prepared by homogeneously mixing the reactive polymer, a compound having a photopolymerizable functional group (monomer and oligomer) and if desired other additives, kneading the mixture using an extruder or roll, and subjecting the kneaded mixture to a film-forming process using a calendar, roll, T-die extrusion or inflation to form a film of a predetermined dimension. The photo-curable transfer sheet having a smooth surface according to the invention can be obtained by extruding the kneaded mixture as mentioned above to cast and cool a sheet having a surface roughness (Ra) of not more than 30nm. If necessary, the other surface may be covered by a sheet (release sheet).

[0062]

Otherwise, the photo-curable transfer sheet can be, for example, obtained by dissolving homogeneously the components in a good solvent, applying the resultant solution onto a separator coated closely with silicone or fluoric resin (support) by means of flow-coater method, roll-coater method, gravure-roll method, mayer-bar method or lip-die coating method, and vaporizing the solvent. Particularly, the photo-curable transfer sheet having a smooth surface can be obtained by applying the resultant solution onto a support (preferably polycarbonate sheet) having a surface roughness

of not more than 30nm, and drying the solution layer.

[0063]

The thickness of the photo-curable transfer layer generally is in the range of 1 to 1,000μm, preferably 5 to 500μm, especially 5 to 300μm (further 150μm or less). When the thickness is thinner than 1μm, sealing properties are lowered and maybe the sheet does not full up the unevenness of the transparent substrate. When the thickness is thicker than 1,200μm, the thickness of the resultant recording medium is so thick whereby trouble in housing or storing of the medium and the resultant assembly or reverse influence in light transmittance possibly occurs.

[0064]

The substrate preferably comprises transparent organic resin having a glass transition temperature of not less than 50°C. The release sheet generally is a transparent resin sheet mainly consisting of organic resin such as polyester resin (e.g., polyethylene terephthalate, polycyclohexylene terephthalate, polyethylene naphthalate), polyamide (e.g., nylon 46, modified nylon 6T, nylon MXD6, polyphthalamide), ketone resin (e.g., polyphenylene sulfide, polythioether sulfone), sulfone resin (e.g., polysulfone, polyether sulfone), polyether nitrile, polyarylate, polyether imide, polyamideimide, polycarbonate, polymethyl methacrylate, triacetylcellulose, polystyrene or polyvinyl chloride. Of these resins, polycarbonate, polymethyl methacrylate, polyvinyl chloride, polystyrene and polyethylene terephthalate can be preferably employed in view of birefringence.

[0065]

The release sheet having a surface roughness of not more than 30nm used in the invention preferably comprises transparent organic resin having a glass transition temperature of not less than 50°C. The substrate generally is a transparent resin sheet mainly consisting of organic resin such as polyester resin (e.g., polyethylene terephthalate, polycyclohexylene terephthalate, polyethylene naphthalate), polyamide (e.g., nylon 46, modi-

fied nylon 6T, nylon MXD6, polyphthalamide), ketone resin (e.g., polyphenylene sulfide, polythioether sulfone), sulfone resin (e.g., polysulfone, polyether sulfone), polyether nitrile, polyarylate, polyether imide, polyamideimide, polycarbonate, polymethyl methacrylate, triacetylcellulose, polystyrene or polyvinyl chloride. Of these resins, polycarbonate, polymethyl methacrylate, polyvinyl chloride, polystyrene and polyethylene terephthalate are excellent in transparenc, and therefore can be preferably employed.

[0066]

The photo-curable transfer sheet of the invention obtained as above generally comprises the photo-curable composition containing the reactive polymer of a glass transition temperature of not more than 20°C. Further, the photo-curable transfer layer generally has a light transmittance of not less than 70% in a wavelength rang of 380 to 800nm. Furthermore, a cured photo-curable transfer layer generally has a light transmittance of not less than 70% in a wavelength rang of 380 to 800nm. In more detail, by setting the glass transition temperature of the reactive polymer to not more than 20°C, the resultant photo-curable transfer sheet having flexibility can follow exactly the uneven surface of the stamper even at room temperature when the sheet is depressed on the stamper. Especially, in the case of the glass transition temperature of 15 to -50°C, the properties following exactly the uneven surface of the stamper is further improved. When the glass transition temperature is so high, high pressure is needed in the depressing or bonding operation whereby the workability is reduced. When the glass transition temperature is so low, the resultant sheet after curing does not have sufficient hardness.

[0067]

As described above, the photo-curable transfer sheet generally has a light transmittance of not less than 70% in a wavelength rang of 380 to 420nm, preferably 380 to 800nm, whereby reduction of the strength of signals to be read out with a laser beam can be prevented. Further, the

sheet preferably has a light transmittance of not less than 80% in a wavelength rang of 380 to 420nm. The same also applies to the cured sheet.

[0068]

The reactive polymer of the photo-curable composition preferably has 1 to 50% by mole of polymerizable functional group, whereby the cured photo-curable transfer sheet has strength capable of holding its shape. The photopolymerization initiator is preferably used in the amount of 0.1 to 10% by weight as described previously. The amount of less than the lower limit causes workability to reduce owing to slow curing rate, whereas the amount of more than the upper limit causes the transfer precision to reduce.

[0069]

The photo-curable transfer sheet of the invention can be offered as a film precisely controlled in the thickness, and therefore it is possible to easily and precisely bond the sheet to the stamper. This bonding can be easily carried out by depressing the sheet and stamper by means of easy method using pressure rollers or easy press to temporarily bond them at temperature of 20 to 100°C, and then curing the sheet by exposing it to light at room temperature for one to tens seconds. Further, the temporarily bonded laminate is free from occurrence of slippage or peeling between of the sheet and stamper or substrate owing to its specific adhesion, and hence the laminate can be freely handled until the light-curing step.

[0070]

In case the photo-curable transfer sheet of the invention is cured, it is possible to adopt, as light source used, various sources generating light in the wavelength range of ultraviolet to visible rays. Examples of the sources include super-high-pressure, high-pressure and low-pressure mercury lamps, a chemical lamp, a xenon lamp, a halogen lamp, a mercury halogen lamp, a carbon arc lamp, and an incandescent electric lamp, and laser beam. The exposing time is generally in the range of a few seconds

to a few minutes, depending upon kinds of the lamp and strength of light.

[0071]

To promote the curing, the laminate may be heated beforehand for 30 to 80°C, and then the heated laminate may be exposed to ultraviolet rays.

[0072]

The metal reflective layer of the invention is formed on an uneven surface of the resultant optical information recording substrate having the uneven surface by metallizing (e.g., spattering, vacuum deposition, ion-plating). Examples of the metal materials include aluminum, gold, silver or alloy thereof. The semitransparent reflective layer provided on the sheet is generally formed by using silver as metal. In more detail, the semitransparent reflective layer is required to have low reflectivity compared with the reflective layer, and therefore is formed by changing the materials and/or the thickness.

[0073]

In case two optical information recording substrates are used, the optical information recording substrate of the invention and a conventional injection-molding substrate are generally used.

[0074]

When two optical information recording substrates having a reflective layer are bonded to each other through adhesive such that the reflective layers face with each other, an adhesive is applied onto one of the reflective layers and the one substrate is superposed on the other substrate, which is cured. When the adhesive is UV-curable resin, it is cured by UV irradiation, and when the adhesive is hot-melt type, it is applied to the reflective layer under heating and then cooled.

In the preparation of the optical information recording medium of the invention, it is continuously processed in the form of sheet and finally punched out in the form of disc. However, it may be processed in the

form of disc when processing under reduced pressure is required.

[0075]

[EXAMPLE]

The invention is illustrated in detail using the following Examples.

[Example 1]

<Preparation of photo-curable transfer sheet>

(Preparation of reactive polymer)

Formulation I

2-ethylhexyl methacrylate	70 parts by weight
methyl methacrylate	20 parts by weight
2-hydroxyethyl methacrylate	10 parts by weight
benzophenone	5 parts by weight
toluene	30 parts by weight
ethyl acetate	30 parts by weight

A mixture of the above Formulation I was heated to 60°C with moderately stirring to initiate the polymerization, and stirred at this temperature for 10 hours to provide acrylic resin having a hydroxyl group on its side chain. Then, 5 parts by weight of Calens MOI (2-isocyanatoethyl methacrylate; available from Showa Denko K.K.) was added to the solution of the acrylic resin, and reacted with each other at 50°C with moderately stirring to provide a solution 1 containing a reactive polymer having a photopolymerizable functional group.

[0076]

The resultant reactive polymer has Tg of 0°C, and 5% by mole of methacryloyl group on its side.

[0077]

Formulation II

solution 1 of reactive polymer	100 parts by weight
tricyclodecane diacrylate	30 parts by weight
1-hydroxycyclohexyl phenyl ketone	1 part by weight

The above Formulation II was homogeneously dissolved to give a mixture, which was applied onto a release sheet (surface roughness Ra=20nm, available from Fujimori Kogyo) and dried. Thus, a photo-curable transfer sheet having release sheet (surface roughness Ra=20nm) of thickness of 100±2μm was prepared.

[0078]

<Preparation of one optical information recording substrate having reflective layer>

The photo-curable transfer sheet was depressed on an unevenness surface of a stamper made of nickel having the uneven surface as pits using a roller made of silicone rubber under load of 2kg to form a laminate in which the shape of the uneven surface was transferred to a surface of the photo-curable transfer sheet.

[0079]

Subsequently, the photo-curable transfer sheet of the laminate was exposed to UV-rays of a metal-halide lamp under the condition of an integrated amount of light of 2,000mJ/cm^2 and as a result, the transferred layer (photo-curable sheet) was cured.

[0080]

The stamper was peeled from the laminate. Silver alloy was spattered on the uneven surface of the cured photo-curable layer (optical information recording substrate) to form a semitransparent reflective layer of silver alloy. Thus, an optical information recording substrate having reflective layer was prepared.

[0081]

<Preparation of the other optical information recording substrate having reflective layer>

Melt carbonate was poured into a mold having an uneven surface as pits and solidified to form an optical information recording substrate having thickness of 1,100μm. Aluminum was spattered on the uneven sur-

face of the optical information recording substrate to form a reflective layer of Al. Thus, the other optical information recording substrate having reflective layer was prepared.

[0082]

<Preparation of optical information recording medium>

A liquid photo-curable adhesive (SD-661; available from DAINIPPON INK AND CHEMICALS, INC.), which is commercially available, was applied onto one of the two optical information recording substrates prepared above by spin coating. The two optical information recording substrates were bonded to each other through the adhesive such that the two reflective layers faced each other to give a laminate, and the laminate was exposed to UV-rays whereby the adhesive was cured. Thus an optical information recording medium (DVD; surface roughness Ra=2nm) was prepared.

[0083]

[Example 2]

<Preparation of photo-curable transfer sheet >

(Preparation of reactive polymer)

<u>Formulation I'</u>

n-hexyl methacrylate	50 parts by weight
2-hydroxyethyl methacrylate	50 parts by weight
benzophenone	5 parts by weight
toluene	30 parts by weight
ethyl acetate	30 parts by weight

A mixture of the above Formulation I' was heated to 60°C with moderately stirring to initiate the polymerization, and stirred at this temperature for 10 hours to provide acrylic resin having a hydroxyl group on its side chain. Then, 50 parts by weight of Calens MOI (2-isocyanatoethyl methacrylate; available from Showa Denko K.K.) was added to the solution of the acrylic resin, and reacted with each other at

50°C with moderately stirring to provide a solution 2 containing a reactive polymer having a photopolymerizable functional group.

[0084]

The resultant reactive polymer has Tg of 5°C and 50% by mole of methacryloyl group on its side.

[0085]

Formulation II'

solution 2 of reactive polymer	100 parts by weight
1,6-hexanediol dimethacrylate	10 parts by weight
1-hydroxycyclohexyl phenyl ketone	1 part by weight

The above Formulation II' was homogeneously dissolved to give a mixture, which was applied onto a release sheet (surface roughness Ra=2nm, thickness: 70μm; trade name: Pure Ace C110-70, available from TEIJIN LTD.) and dried. Thus, a photo-curable transfer sheet (surface roughness Ra=2nm) having thickness of 100±2μm was prepared.

[0086]

One and the other optical information recording substrates having reflective layer and an optical information recording medium were prepared in the same manner as Example 1 by using the resultant transfer sheet. Thus an optical information recording medium (DVD; surface roughness Ra=2nm) was prepared.

[0087]

[Comparison Example 1]

The above Formulation I obtained in Example 5 was homogeneously dissolved to give a mixture, which was applied onto a release sheet made of polyester (surface roughness Ra=33nm, thickness: 70μm; MRF-50, available from TEIJIN LTD.) and dried. Thus, a photo-curable transfer sheet having release sheet (surface roughness Ra=33nm) of thickness of 100±2μm was prepared.

[0088]

Subsequently, one and the other optical information recording substrates having reflective layer and an optical information recording medium were prepared in the same manner as Example 1 by using the resultant transfer sheet. And an optical information recording medium was prepared in the same manner as Example 1.

[0089]

[Example 3]

On the exposed surface (reproduction side) of the optical information recording medium obtained in Comparison Example 1, a hard-coat liquid solution (Seikabeam VDAL292, available from) was applied by spin coating, and exposed to UV.

[0090]

The surface roughness (Ra: center-line average roughness) of each of Examples 1 to 3 and Comparison Example 1 was determined below.

[0091]

Measuring method of surface roughness:

Ra (center-line average roughness) of the sheet was measured by using a contact-type surface-roughness instrument (Talystep; available from Taylor Hobson).

[0092]

<Evaluation of optical information recording substrate and medium>

(1) Light transmittance (wavelength of 380 to 420 nm)

Light transmittance of the resultant photo-curable transfer sheet is measured in the wavelength of 380 to 420 nm according to JIS K6717. Light transmittance of 80% or more is marked as ○, and Light transmittance of less than 80% is marked as ×.

[0093]

(2) Roughness of land portion

A land portion of an uneven surface on which pits were formed is evaluated on its smoothness using AFM (atomic force microscope). Land

portion having sufficient smoothness is marked as ○, and land portion having poor smoothness is marked as ×.

[0094]

(3) Readout of signals

The information of the resultant optical information recording medium is read out using a laser beam of wavelength of 405nm to obtain its wavy pattern. This wavy pattern is compared with that of the stamper. The wavy pattern of the medium coincident with that of the stamper is marked as ○, and the wavy pattern of the medium little coincident with that of the stamper is marked as ×.

[0095]

The obtained results are shown in Table 1.

[0096]

Table 1

	Example 1	Example 2	Example 3	Co. Example 1
Light transmittance (380-420nm)	○	○	○	○
Roughness of land	○	○	○	○
Readout of signals	○	○	○	×

[Effect of the invention]

[0097]

As shown above, the photo-curable transfer sheet according to the invention is depressed on an uneven shape of a stamper for preparing an optical information recording substrate to precisely follow the uneven surface, and therefore the uneven surface is precisely transferred to the surface of the transfer sheet, and simultaneously the adhesive sheet has an extremely smooth reverse surface having no unevenness. Thus the resultant optical information recording medium or substrate has a signal surface (uneven surface) to which the unevenness of the stamper has be precisely

transferred and an extremely smooth reverse side (surface) corresponding to a laser-irradiation-side. Accordingly, the resultant optical information recording medium scarcely brings about occurrence of errors when the information (signals) is recorded or read out.

[0098]

Further, the optical information recording medium or substrate obtained by the invention is formed by deforming the photo-curable transfer sheet by melting and curing it to form an uneven surface, and therefore even the optical information recording substrate having a thickness of 300μm or less can be prepared with excellent transferring.

[Brief Description of the Drawings]

[Fig. 1] Fig. 1 is a section view showing an example of an embodiment of a photo-curable transfer sheet according to the present invention.

[Fig. 2] Fig. 2 is a section view showing an example of the optical information recording substrate and the laminate of the invention.

[Fig. 3] Fig. 3 is a section view showing an example of a process for the preparation of the optical information recording medium of the invention.

[Fig. 4] Fig. 4 is a section view showing another example of the optical information recording medium of the invention.

[Fig. 5] Fig. 5 is a schematic view for explaining a depressing method using a device according to a double vacuum chamber system.

[Fig. 6] Fig. 6 is a section view showing an example of a conventional optical information recording medium.

[Fig. 7] Fig. 7 is a section view showing another example of a conventional optical information recording medium.

[Brief Description of the reference numbers]

11: Photo-curable transfer sheet

20: Photo-curable transfer sheet having uneven surface (Optical information recording substrate)

12a, 12b: Release sheet

12c: Support

13: Silver alloy reflective layer

30: Optical information recording substrate

40: Optical information recording medium

21: Stamper

33: Al reflective layer

34: Adhesive layer

1, 2: Transparent resin substrate

1a, 2a: Reflective layer (or recording layer)

3: Adhesive layer

1b: Semitransparent layer

[Title of Document] Abstract

[Abstract]

[Object]

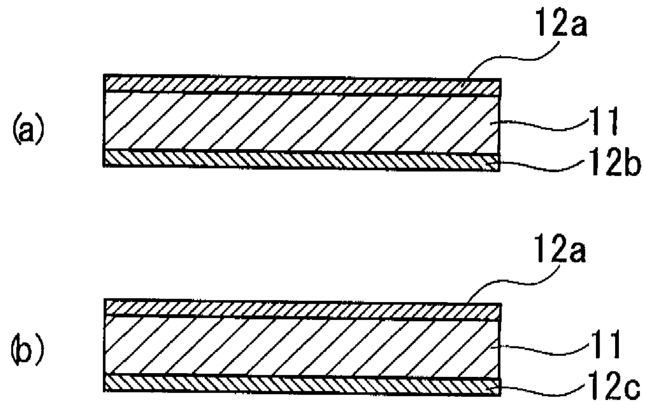
The object of a third aspect of the invention is to provide an optical information recording medium having precisely formed pit signals and/or groove on one side and excellent smoothness on the other side (laser-irradiation side).

[Means for Achieving the Object]

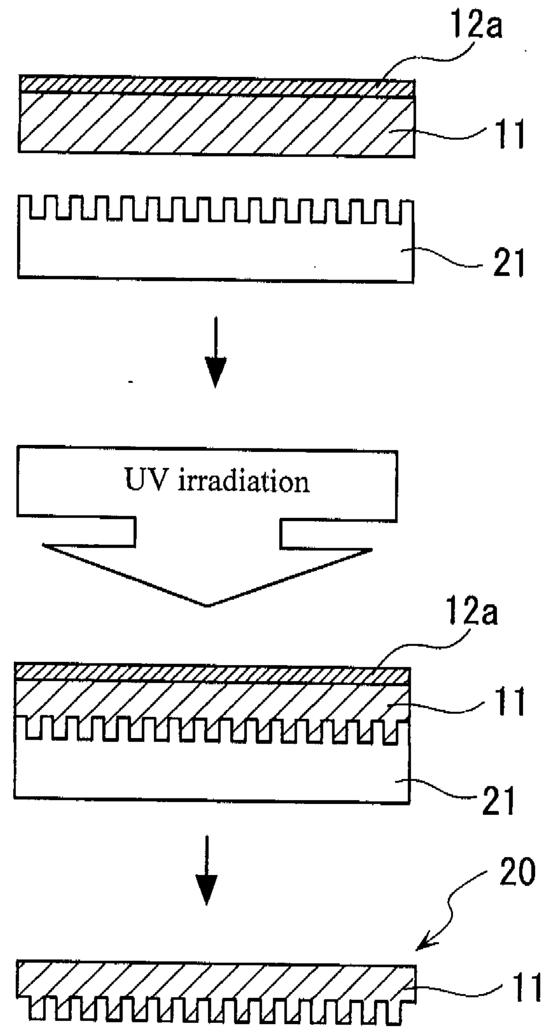
An optical information recording medium comprising a cured film of the photo-curable transfer sheet comprising a photo-curable composition which comprises a reactive polymer having a photopolymerizable functional group and which is capable of deforming by application of pressure, the uneven surface and a reversed surface (side) of the cured layer having a surface roughness (Ra) of not more than 30nm; or wherein a coated and cured layer of UV curable resin is provided on a reversed side of the cured film, the cured layer of UV curable resin having a surface roughness (Ra) of not more than 30nm.

[Selected Figure] Fig. 1

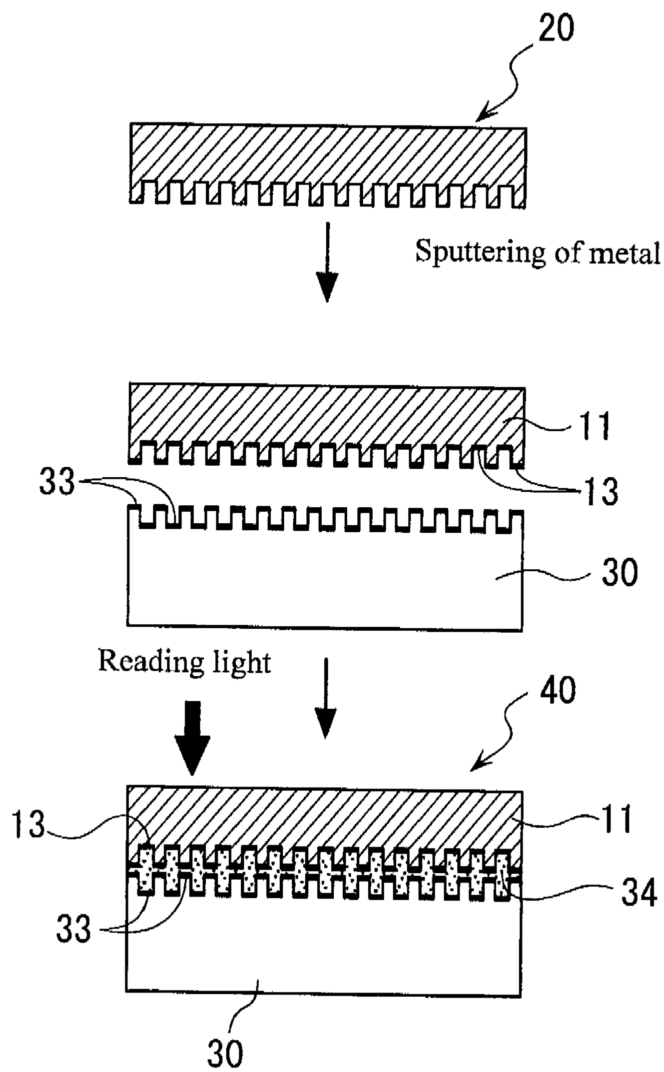
【Fig.1】



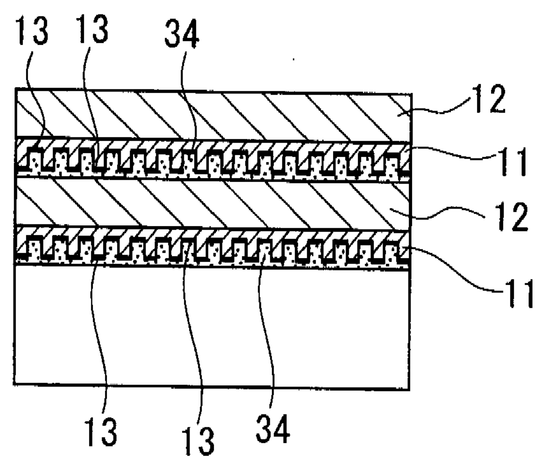
【Fig.2】



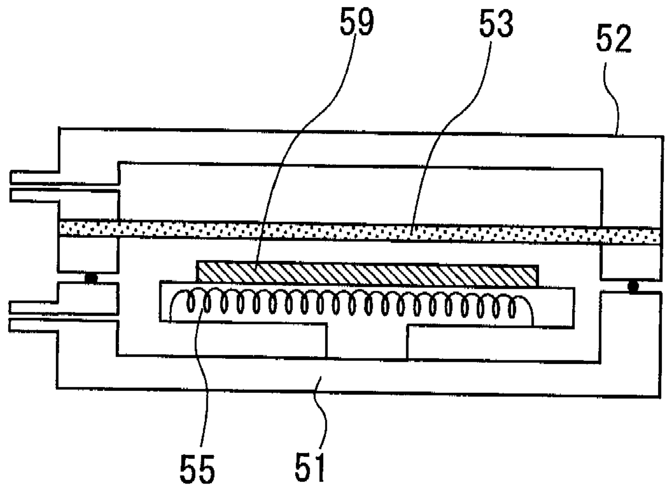
【Fig.3】


20
Sputtering of metal
11
33
13
30
Reading light
40
13
11
34
33
30

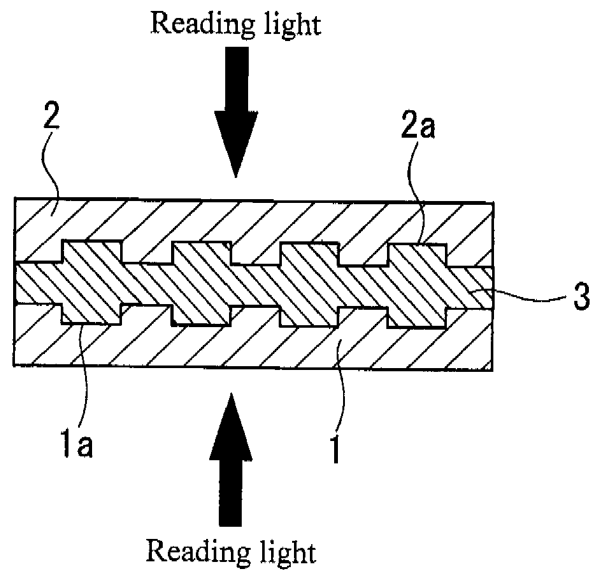
【Fig.4】


13
13
34
12
11
12
11
13
13
34

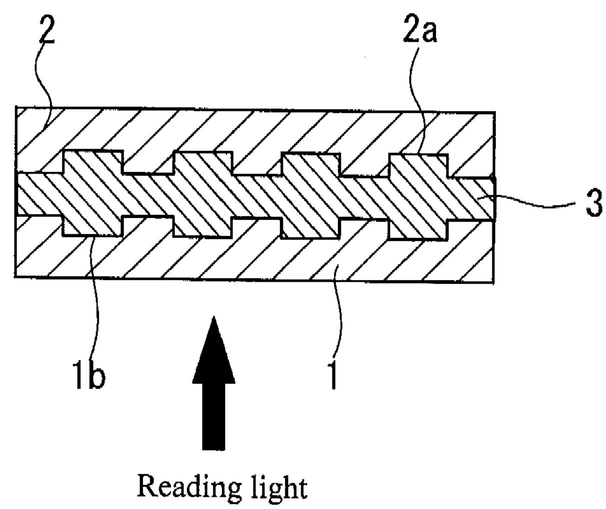
【Fig.5】



【Fig.6】


Reading light
2
2a
3
1a
1
Reading light

【Fig.7】


2
2a
3
1b
1
Reading light